

# An Investigation of Primary School Teachers' PCK towards Science Subjects Using an Inquiry-Based Approach\*

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## Abstract

In this study, the pedagogical content knowledge (PCK) of four experienced primary school teachers was investigated within the "Let's Solve the Riddle of Our Body Unit". The PCK investigation adopted a learning approach based on inquiry, content representation and pedagogical and professional-experience repertoires (PaP-eRs), and interview forms were used as data collection tools. During the course of the research, the findings obtained from observations made during a total of 18 course hours formed the basic data source of the study. According to the results of the study, in which descriptive and content analysis were used concurrently, primary school teachers lack subject matter knowledge, do not interrogate the pre-knowledge of students and some misconceptions exist regarding about blood moves and exercise with pulse. Additionally, some deficiencies were detected in the curriculum, i.e., it offers non-inquisitional knowledge. Furthermore, teachers employ assessment methods with traditional teaching methods and techniques. In the context of an inquiry-based learning approach, teachers appeared to believe that classroom activities were adversely affected by the physical conditions (class size, lack of laboratory etc.), students' cognitive levels and parent profiles. The result of this study revealed that PCK components affect one another. The PCK findings pertaining to primary school teachers as it concerns the unit are briefly discussed and some suggestions about the development of PCK are submitted.

**Keywords:** Pedagogical content knowledge; inquiry-based approach; primary school teacher; science; teacher competencies

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## Introduction

Teacher competency is an effective factor on student behaviour and learning, and also plays a role in pedagogical progress and student learning. What pedagogical knowledge is and how teachers perceive their own pedagogy must be considered a separate component of pedagogical content knowledge. According to the pedagogical content knowledge (PCK)

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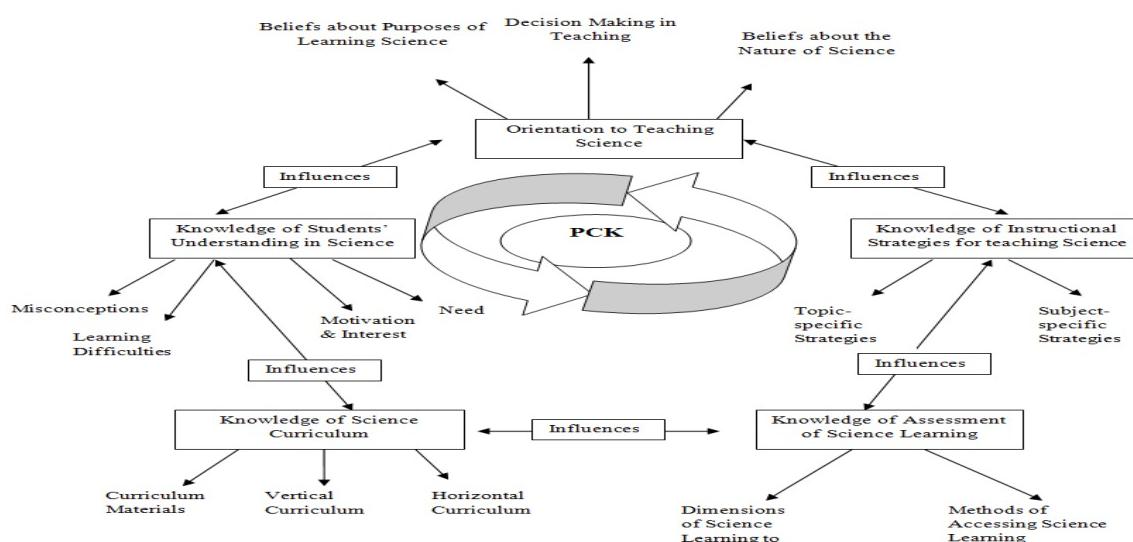
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description by Shulman (1987), it is important to arrange the content knowledge owned by the teacher according to the interests and needs of students. This can be done by using alternative approaches to such as analogy, demonstration and simulation and the transfer of knowledge. In accordance with Hope and Townsend (1983), a matter that must be considered at this point is being knowledgeable about what students think about, because misconceptions on the part of the teacher can have a negative effect in the pre-knowledge and comprehension deficiencies of the students. The instructional strategies used by the teacher during courses serve as indicators of being a specialist in the identification and elimination of existing misconceptions (Magnusson, Krajcik, & Borko, 1999); therefore, PCK has multiple dimensions.

Shulman (1987) continued to expand on PCK definitions by adding different dimensions from the approach initiated by Magnusson and others (1999). While emphasizing subject matter knowledge (SMK), which is important in science learning and teaching, a complete consensus among the various models developed cannot be ensured (Abell, 2007; Smith, 1999; van Driel, Verloop & De Vos, 1998). Despite this, two primary components are agreed upon in PCK studies; these focus on the knowledge pertaining to students' understanding and the available research on SMK (van Driel et al., 1998).

Moving on from the basic elements, different models – in which different aspects related to PCK are highlighted – have been developed (Cochran, DeRuiter & King, 1993; Cochran, King & DeRuiter, 1991; Grossman, 1990; Marks, 1990; Tamir, 1998). These models suggest that components can be analysed independently or together. As a result, a complete definition of PCK cannot be formulated.

In order to classify as PCK, shown below all components must be independently evaluated using a holistic approach. PCK understand to be considered independently of each ingredient is essentially the same time evaluating a holistic approach. Park and Chen (2012) developed a pentagon model that highlights the importance of integrating components, thereby creating synthesis among all PCK components (Figure 1).



**Figure 1.** Pentagon model of PCK for teaching science (Park & Chen, 2012, p.925).

In the pentagon model, knowledge of students' understanding, orientation to teaching science, knowledge of instructional strategies for teaching science, knowledge of assessment of science learning and knowledge of assessment of science learning components are included and analysed as a whole in PCK studies. This inclusion of all components in an equally-weighted manner provides strong consistency (Park & Chen,

2012). To dominate the current curriculum of teachers and make the necessary adjustments and guidance in this respect is related to the curriculum knowledge component of PCK (Falk, 2011); this reveals the skills of the teacher as it concerns curriculum concepts (Park & Oliver, 2008b).

The component of science education assessment reflects the status of learners using an approach that includes appropriate measurement tools and activities and methods in line with the current curriculum (Park & Oliver, 2008b). For students to understand the basic components of PCK, teachers are required to have good SMK and knowledge about student behaviours related to this knowledge (Driel, Jong, & Verloop, 2002). When considered in terms of these components, good teaching strategies dismiss misconceptions about conceptions.

Science teaching strategies includes learning cycles, conceptual change strategies and the inquiry-based approach as a whole (Park & Oliver, 2008b). Orientation information for science education covers instructional decisions. Beliefs about the nature of science and faith for science education and PCK knowledge is a component that cannot be discussed separately from SMK, because it may include information about PCK by making teaching experiences monitoring through the investigations of the SMK (Driel, Jong, & Verloop, 2002). Indeed, several researchers have concluded that there is a deficiency among PCK components due to about SMK causes lack (Cohen & Yarden, 2009; Jones & Moreland, 2004; Sperandeo-Mineo, Fazio & Tarantino, 2005; Veal & Kubosko, 2003). Hence, in PCK studies, SMK cannot be considered separately from these components.

When considering the relevant literature studies, the effects of various experiences, applications and models on the development process of PCK (Henze, Van Driel & Verloop, 2008; Nilsson, 2008), the effect of SMK on PCK and their mutual interactions (Rollnick, Bennett, Rhemtula, Dharsey & Ndlovu, 2008; Sperandeo-Mineo et al., 2005), as well as the PCK status of teachers in general or about a certain subject were examined (Lee, Brown, Luft & Roehrig, 2007; Lee & Luft, 2008). Overall, considering all of the studies involved, research about PCK concerning primary school teachers, who present science lessons at the primary level, were included in abundance and it was observed that the relationship between PCK components among these teachers have not been sufficiently examined. In addition, studies carried out that focus on specific subject matter in PCK were individually assessed and a number of components were examined (Mulhall, Berry & Loughran, 2003).

In Turkey, the middle school science curriculum was revised in 2013 and an inquiry-based approach was adopted. With this new approach, a basic vision expressed as "to train all students to be science literate individuals" (The Ministry of National Education, 2013) was developed.

An inquiry-based approach plays an important role in obtaining desirable outcomes for student achievement. A "pedagogy of joint discovery" (Levy & Petrulis, 2012) approach is important for the development of critical thinking among students and for the advancement of intellectual and practical skills required for life. Therefore, teachers play a role in the development of in-depth understanding among students, using the appropriate tools to do so and for transferring information; at the same time, students are responsible for their own learning, assessment and for designing a research and questioning process at the centre of their learning. As such, the PCK framework of this study constitutes the details pertaining to how teachers employ a status of inquiry-based approach in their courses. From this perspective, the question, "How is the PCK of primary school teachers geared toward the "Let's Solve the Riddle of Our Body Unit" in terms of employing an inquiry-based approach?" constitutes the problem statement of the current study, based on the pentagon model.

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## Method

In this study – conducted to examine the PCK of primary school teachers in the “Let’s Solve the Riddle of Our Body Unit” in terms of the inquiry-based approach – qualitative research and a case study were employed as a research design. The unit of analysis in this study was primary school teachers and included more than one case. Thus, a “multiple case design” (Yin, 2003, p.34) was employed for this research. The study was conducted among fourth grade primary school teachers and the study group was selected from teachers who worked in the village and town centres of Tokat Province (Turkey) by using purposive sampling techniques. In purposive sampling, variables such as seniority/length of service of primary school teachers teaching fourth grade students and the campus of the school and how many times they taught the fourth grade were taken as a basis for volunteer. By doing so, it was assumed that the teachers with different cultural structures would participate in the study and that this would reveal the different dimensions of the problem under study. Study participants are introduced below in detail and were observed during eight acquisitions and 18 course hours in total by placing cameras in class. The data related to PCK were collected using other data collection tools.

### *Participants*

The group under study comprised three female and one male primary school teachers working in different areas of Tokat Province during the 2015-2016 academic year and teaching fourth grade. Participants were given code names within the study group; their demographic knowledge and statements that reflected them are shown in Table 1. When creating the study group, we preferred selecting fourth grade teachers who applied the 2013 revised science lesson curriculum. At the point of selecting participants, a criterion-sampling technique was used. In criteria sampling, variables such as seniority/length of service of the primary school teachers teaching fourth grade students, the campus of the school and how many times they taught the fourth grade were taken as a foundation for volunteer. For this reason, some criteria such as teachers teaching at the fourth grade level and having at least five years of experience were taken into account. By doing so, it was ensured that divergently equipped teachers took part in the study and that as a result, different dimensions of the problem would arise.

**Table 1.** Participant demographics

Code name	Zeynep	Ozge	Serkan	Esra
Gender	Female	Female	Male	Female
Age	31	35	60	53
Professional seniority	8 years	14 years	37 years	32 years
Working time at school (years)	3	9	9	15
Number of students	12	10	39	10
Fourth grade teaching experience	3	6	8	9
Graduation programmes	Faculty of Education	Faculty of Education	Graduate School of Education	Graduate School of Education

Zeynep had always taught in multi-grade classes. They taught fourth grade in combined classes and Zeynep stated that she had taught fourth grade independently for the first time in the school where she is currently employed. Zeynep described herself as a teacher who did not follow new methods and techniques and who engages in courses without preparation.

Ozge stated that she had taught fourth grade four times as a combined class and twice independently. As a teacher, she described herself as motherly and a person who ascribes importance to awards.

Serkan stated he had taught fourth grade students seven or eight times. As a teacher, he described himself as someone who valued his students.

Esra stated she had taught fourth grade students nine times in a consolidated class. As a teacher, she described herself as someone who saw herself as a friend to her students and as a teacher who takes an interest in their problems.

#### *Data Collection and Analysis*

In the study, observations, interviews and document analysis were included as data collection methods and content representation; also included were PaP-eRs, interviews and several types of written materials applied by the teachers in their classes.

*Content representation (CoRe):* content representation helps the teachers to demonstrate their teaching approach to the subject and questions the reasons for the specific approach applied. The CoRe table developed by Loughran et al. (2012) indicates big ideas about a subject in the top column, with teaching-related items below it. In this table, information such as big ideas, planning what to teach students related to these ideas, why the information is necessary for students, various ideas about the subject being taught, limitations and challenges concerning knowledge, awareness of students' ideas, the factors involved in teaching the ideas and special education procedures are examined. The statements made in the content representation section were conveyed to lecturers who have researched the field of PCK (two professors and one associate professor) via e-mail and expert opinions (two teachers) were obtained to test its intelligibility. Following the proposed corrections, it was applied by giving the final version.

*PaP-eRs:* Loughran et al. (2012) suggest using PaP-eRs (pedagogical and professional-experience repertoires) for determining pedagogical content knowledge. As a means of expression, PaP-eRs is also important as a methodology, evident by the different stages of teaching scenarios exhibited by teachers in PaP-eRs tables. Therefore, based on the different formats (at that time, the students' actions, lesson plans, etc.), the teacher's pedagogical knowledge and concept presentations can be revealed (Loughran et al., 2000).

Though content representation and PaP-eRs cannot fully reveal the axioms of teachers, it is possible to argue that these methods demonstrate teachers' beliefs about their PCKs, as well as their reflections about their application (Mulhall, Berry & Loughran, 2003).

*Interview form:* the interview form, prepared to reveal the PCKs of the primary school teachers in science subjects and using the inquiry-based approach, questions were prepared in the context of orientation pertaining to science teaching, students' understanding of science knowledge, teaching strategies, knowledge about teaching science, as well as knowledge about science learning assessments and curriculum knowledge. Prior to the prepared questions being applied, expert opinions were collected; the questions were then applied to two primary school teachers and a pilot study was conducted. To gain expert opinions, we contacted a science educator professor, an associate professor and two assistant professors who have completed studies on PCK. The face-to-face interviews were audio-recorded and then the data were converted into written form. The data obtained from the interviews were analysed using content analysis.

In this study, both descriptive and content analyses were used. The data obtained from the observation form and CoRe tables were subjected to descriptive analysis. Data gathered from the interviews were converted into written form from voice recording. Using an

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inductive approach to interview form, for this was first coding and free coding was applied by the researcher, the obtained codes were collected through specific groups and finally, themes were noted. The Nvivo 10.0 data analysis software was applied to save time during the data analysis process and to better organize the process. A short sample of applied codes is shown in Appendix A.

#### *Reliability and Validity*

To ensure the reliability and validity of the study, a focused literature review was conducted; several data collection tools were employed and findings were checked for consistency once participants confirmed the findings. A working group was introduced and by describing the work environment, data were gathered from observations and interviews. During the analysis of interview questions, raw data were coded and emergent themes were given meaning by reviewing the literature. In addition to creating codes, teachers' statements were exemplified using one-to-one sentences (Appendix A). After completing the coding process, codes and themes were sent to an independent coder. The codes of these two coders were then compared using the Nvivo software and Cohen's kappa coefficient was calculated. The reason for using this coefficient during calculations is that it allows for comparing codes applied by only two people (Bazeley & Jackson, 2015). During the study, 39 codes were gathered and 35 were in agreement. While code agreement was calculated as  $35/39=0.89$ , Cohen's kappa coefficient was determined as 0.81. According to Bazeley and Jackson (2015), a kappa-1 value shows perfect agreement, while other values close to this result are qualified as also having near perfect agreement. It is therefore possible to say that the applied codes in this study were reliable.

#### **Findings**

The content representation forms completed by participant teachers regarding the "Let's Solve the Riddle of Our Body Unit" are presented in Appendix B. According to the data obtained from Appendix B, teachers stated that they planned to teach students about the types of joint, bone and muscles related to the unit. However, these issues were not included in fourth grade science achievements. Similarly, they stated that students will experience difficulty understanding the vessel types, which were not included among the for fourth grade achievements. Teachers stated that they used mainly question-and-answer, discussion, experiments, observation, presentation, watching slides and reading and narration as methods and techniques. Additionally, when the participant primary school teachers were asked to recommend alternative methods and techniques, they noted the optimal ways in the classroom conditions and that animated cartoons and presentations must be presented for students to understand the information better. When the documents that participant teachers used in their classes were analysed it was observed that they prepared too many quantitative questions. Additionally, they gave weight to knowledge-level questions but did not focus on synthesis or higher level questions. Only Serkan prepared questions at the analysis level; Ozge prepared questions from Bloom taxonomy's initial three levels. Apart from Serkan, all the other teachers downloaded ready-made questions from education sites. Apart from Ozge, all other teachers included questions unlike of acquisition in their exams, which concerned bone types.

The PaP-eRs analysis form was prepared using camera records of the primary school teacher participants, as well as the written documents they used in their classrooms (Appendix C). When the PaP-eRs form and document examination was created, it was observed that the participant teachers used ready-made questions and curriculum unlike of acquisition in their classroom activities. Additionally, it was observed that they had misconceptions about the subjects of tooth structure, blood circulation, breathing

correctly and about the ingredients of the arterial and venous blood and joint structures, and as such, were likely unaware of students' misconceptions.

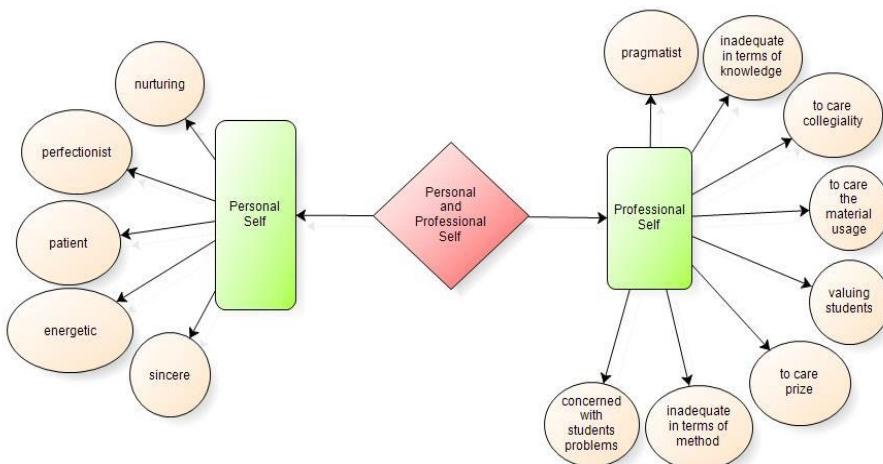
Zeynep used traditional teaching methods and techniques to teach the unit and could not evaluate sufficiently. She was unable to help her students sufficiently regarding the contraction and relaxation of muscles, vascular structures and blood circulation. Additionally, she taught unlike the acquisition and as a result, had misconceptions about the structure of the tooth, blood circulation and breathing. Since she was unprepared for the lesson, it was observed that she did not use inquiry-based teaching. In addition to not having enough information about blood structure, Ozge did not allow her students to ask questions during her lessons. Ozge always used educational videos; however, she simply let her students watch these without commenting on them and did not use an inquiry-based approach. Ozge was therefore inadequate in her teaching as it concerned content knowledge, which she stated during the interview.

Serkan was observed as entirely employing traditional teaching methods. He also stated during the interview that he did not know any inquiry-based methods and that was unable to make adequate assessments. Additionally, he had misconceptions about joints. As he had inadequate information about the unit's content, he did not move beyond using the textbook.

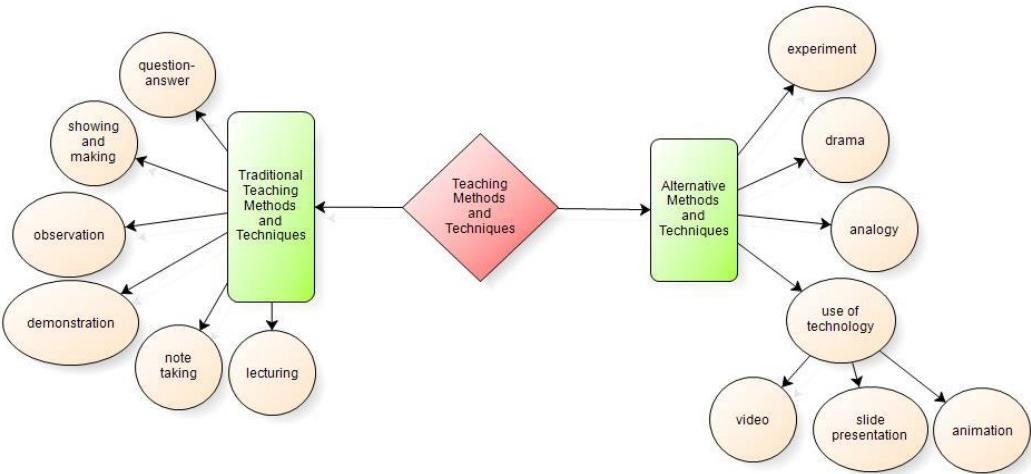
Esra used quite many analogies in her classes, conducted experiments and enabled children to effect research and ask questions. However, by teaching outside the content of the unit, Esra was unable to sufficiently evaluate the research and questioning skills of students.

Teachers presenting in formation unlike the acquisition, as well as missing information, is associated with a lack of SMK. It also emerged that, when evaluating science learning, traditional teaching methods and techniques were being used.

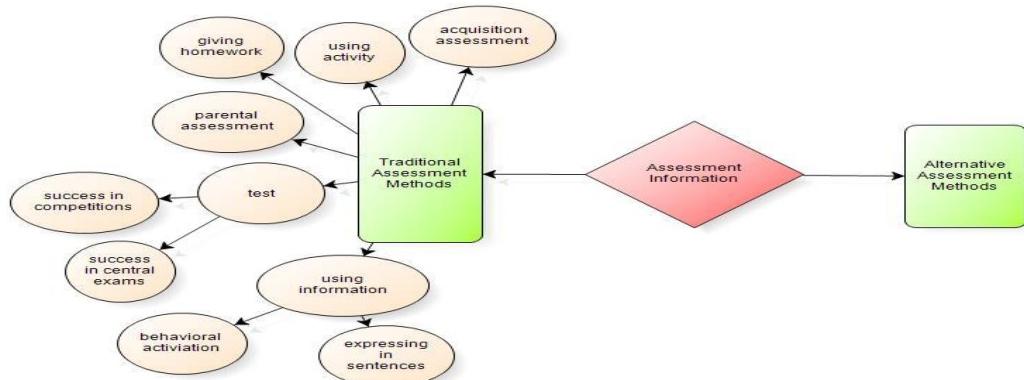
As a result of the interviews conducted with the participating primary school teachers, the model presented in Figure 2 was created. The model addresses personal and professional self-esteem, teaching methods and techniques, assessment information, programme information and the obstacles present in the learning environment.



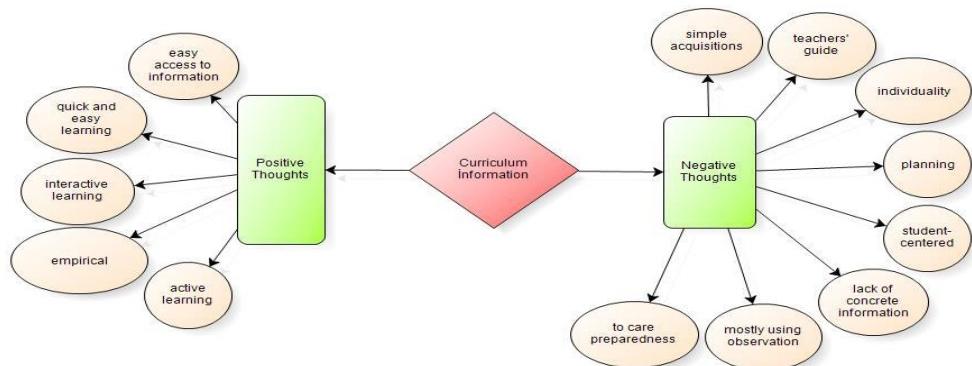
**Figure2.1.** Teachers' personal and professional perceptions about themselves.



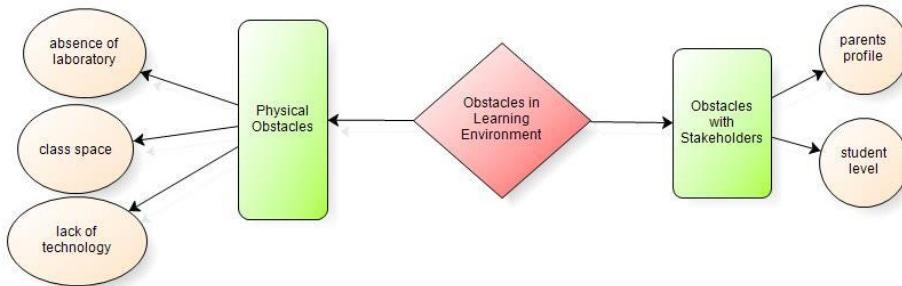
**Figure 2.2.** *Teaching methods and techniques adopted by the teachers.*



**Figure 2.3.** *Teachers' approaches to evaluating scientific understanding.*



**Figure 2.4.** *Teachers' thoughts about the programme.*



**Figure 2.5.** Obstacles present in the learning environment according to teachers.

As shown in Figure 2.1, the primary school teachers evaluated themselves teaching based on inquiry-based approach. According to two sub-dimensions, i.e., personal and self-esteem in terms of their. When the professional esteem dimension was examined, it was noted that teachers viewed themselves inadequately in terms of pedagogical components and conducted teaching based on a behavioural approach. Teachers expressed their personal and professional features as follows:

*"I think of the students as my own children... I act as a motherly teacher... While teaching fourth grade subjects, I care about teaching one step further from the level of the students... I provide more information and sometimes this can be problematic." (Zeynep)*

*"I always act like a mother to my students... they are like my sons and daughters and I believe rewarding them is very important for their education." (Ozge)*

*"Above all, I accept my students for who they are. This is because... I am a mother. Depending on the situation, I sometimes act like their mother and sometimes their friend. Of course, I set boundaries to our relations and behave accordingly. I am sincere. I am trying to be interested in all their problems, not only my students' problems but also that of their families as much as this is possible." (Esra)*

*"I view myself as a well-intentioned teacher... I place importance on my students... I love them and I try to teach them as best as I can." (Serkan)*

The participant teachers were asked whether there had been any changes to their teaching methods and techniques, compared to approaches that were in line with the revised programme; this resulted in the model shown by Figure 2.2. According to this model, primary school teachers stated that they did not experience many changes and that the traditional teaching methods (question-and-answer, demonstrations, observation, taking notes and delivering lectures) were more practical and that pedagogically, inquiry-based approach did not affect them. Serkan stated about the methods and techniques he used:

*"The students must take notes or the teacher must write on the board or the teacher must let students take notes as a means of summarizing the subject."*

On the other hand, Esra said that she had not changed her approach to teaching because she did not believe that new teaching methods and techniques were innovative. Esra stated her ideas as follows:

*"I think new methods and techniques are simply old techniques with new names. Of course I should try different techniques, but sometimes, what we say is "innovative" is simply a time consuming activity. I am not sure whether I can try new methods in crowded classrooms. Therefore, instead of being innovative, I consider how much a method is practical and applicable."*

Primary school teachers were asked to evaluate science education in line with the changing programme and the new approach brought about by PCK components, which delivered the model shown in Figure 2.3. All of the teachers stated that they did not

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employ the science education method as suggested by the approach based on inquiry and that they primarily used tests. On this subject, Ozge stated:

*"I don't know a matter of interest... I do not think that the students can learn much through the project and performance work in science lessons... The students' successes is associated with teachers' successes. If the students perform well in the exam, the teacher is also considered as having been successful."*

Serkan evaluated students' science assessments according to changes in their behaviours. His ideas were expressed as follow:

*"The student reflects what he/she has learned similar to a mirror. To what extent can he/she reflect what they see, the acquisitions they have made and the changes in behaviour they have effected? It is a significant process when students reflect what they have learned through their behaviour."*

The teachers' thoughts about the new science curriculum (revised in 2013) and the basic approach adopted by it are shown in the model in Figure 2.4. Accordingly, the negative thoughts of teachers about the education programme outweighed their positive responses; they particularly did not like being easy of the acquisitions. However, they were satisfied about making allowance for quick and easy learning and being ready of all kinds of knowledge (such as internet) in their hand. Ozge stated about the programme:

*"It is good...science lesson and a simplified one the acquisitions given to us let us to give something but I sometimes say that they not be so easy...I am experiencing difficulty getting used to this programme."*

Esra stated her ideas about the newly adopted programme and inquiry-based approach as follow:

*"When the aim of a new programme is given it very good but when I look at back to my students they cannot produce new knowledge by using the provided knowledge and were not able to solve the problem."*

In line with the programme revised for the participant primary school teachers, they were asked about the cases that hindered their learning and education, which resulted in the above model (Figure 2.5). Accordingly, teachers primarily mentioned physical obstacles and highlighted parents' profiles, which they prescribed importance to for the evaluation of science education. Serkan's statements about this matter were as follows:

*"The current conditions and facilities of the schools, the acquisitions and research studies are not sufficient for applying all of the innovations that have occurred for science lessons. You saw that we have to fit 39 students into a very small classroom and must teach accordingly."*

According to Ozge, obstacles to science teaching include school administration, crowded classrooms and the lack of a laboratory. Ozge's stated:

*"Schools are difficult in the centre of Tokat...because of the crowded classrooms. In villages it is difficult because of a lack of material. If I take a class with 35-40 students and try to give different materials to each of them within a big school, the school administration will be unhappy. I believe that it is necessary to plan the use of a laboratory for each lesson. Consider the nature of fourth grade classes and their science lesson hour and that in some schools, both primary and elementary schools are together in the same building. City schools quickly become overcrowded but for schools in villages, classrooms are not as crowded... However, there is a different problem lack of materials."*

## **Results and Discussion**

Taking an inquiry-based approach to the participant primary school teachers in the context of the "Let's Solve the Riddle of Our Body Unit", this study conclude the presence of some deficiencies in both SMK and PCK. It was observed that teachers were not able to

fully judge the subject of the unit and this case is effective on their PCK. Indeed, SMK is a prerequisite in the development of PCK. The deficiencies observed in SMK led teachers to solve fewer problems and to use less effective teaching strategies. Moreover, this prevented them from being adequate in terms of understanding students' level of knowledge (Kind, 2009).

According to Childs and McNicholl (2007) and Gess-Newsome and Lederman (1999), teaching strategies are affected by SMK. In the literature, many studies were found to support the conclusion that a lack of SMK affects PCK components (Cohen & Yarden, 2009; Kamen, 1996; Matese, 2005). In addition, it was observed that several teachers conducted their classes without any prior preparation. Being aware of students' misconceptions and understanding their level of knowledge is important for teachers in order to develop effective teaching plans; it is also effective for determining existing misconceptions among students and knowing why students behave in a certain manner (Halim & Meerah, 2002).

This study shows that teachers held some misconceptions about the unit; as such, they lacked knowledge about students' level of understanding. Berg and Brouwer (1991) conducted their study, have done with physics teachers and students are unaware of the misconceptions revealed that even led to the wrong student learning in their own misconceptions. Smith and Neale (1991) also tested similar findings about the knowledge of primary school teachers about light and shadow subject. Teachers with deficient concept knowledge are insufficient at constructing information for students, at formulating appropriate questions, creating alternative explanations and structuring questioning. To discover whether science concepts are being understood in-depth, students' understanding must be properly evaluated, while pinpointing misconceptions at the same time. Among teachers weak concept knowledge leads to anxiety, less effective teaching and a decrease in self-sufficiency (Czerniak & Chiarelott, 1999).

Participant primary school teachers used traditional teaching methods and techniques during the unit and stated this to be the case during the interviews. Only one of the teachers used primarily technology to present classes; however, while doing this, she left the students completely inactive, because the video presentations and animations that she allowed them to watch effectively replaced the teacher in the classroom, with students effectively becoming no more than spectators. This situation led to not many questions being asked, while in the classes of other teachers led to unanswered questions.

Knowledge of science teaching strategies can help teachers and students to better learn scientific concepts. However, incorrect analogies and examples revealed the misconceptions held by some teachers (Gess- Newsome & Lederman, 1999). According to Magnusson, Borko and Krajcik (1999), using teaching strategies correctly is important for ensuring the conceptual understanding of students. Different activities conducted in the classroom can also have a positive effect on the comprehension challenges pertaining to the knowledge acquired by students (Grossman, 1990; Lederman, Gess-Newsome & Latz, 1994).

As seen in the information provided by the participant primary school teachers via the interviews and CoRe, as well as the PaP-eRs analysis form, they were unable to evaluate science education. They also continued using traditional methods in the context of an inquiry-based approach. The evaluation methods used by teachers are an important element in the development of their PCK, because teachers acquire knowledge regarding learning purposes through the evaluation methods they employ. Instruction strategies can be monitored more closely through appropriate evaluation. Some of the teaching materials employed by teachers supported their teaching strategies. Thus, teachers' knowledge of evaluation contributes to their professional development and is also important for the

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development and configuration of students understanding the knowledge conferred to them (Falk, 2011). As noted in many studies that support the correlation between the evaluation of knowledge and students' understanding (Atkin, Coffey, Moorthy, Sato & Thibeault, 2005; Tabachnick & Zeichner, 1999), PCK components are interrelated. This study reached the same conclusion. In a study by Bayer and Davis (2011) involving science subjects and conducted with primary school teacher candidates, it was concluded that teachers had insufficient science evaluation knowledge.

Considering the component of science curriculum knowledge related to "Let's Solve the Riddle of Our Body Unit", the conclusion reached is that teachers were unaware of the acquisitions in the curriculum that they stated in the CoRe, as was observed in the PaP-eRs analysis. Indeed, in the interviews, teachers mentioned that they were not satisfied with only the simple knowledge acquisitions related to the revised programme and that they added additional acquisitions of their own. However, achieving success with the added acquisitions had not been successful. This study therefore concludes that the primary school teachers who participated in this study lacked the proper science curriculum components. This information is important in terms of teachers having a good command of their subject, changing and orienting activities and providing sufficient conceptual knowledge transfer (Park & Oliver, 2008b). In a study involving science teachers and pertaining to a breakdown of the ozone layer, Bozkurt and Kaya (2008) found similar conclusions. They investigated students' understanding of the knowledge involved, their curriculum knowledge and teaching strategies knowledge pertaining to SMK and PCK. The study also concluded that candidate teachers had misconceptions about the subject being taught. SMK is effective for the development of pedagogical strategies as it concerns teacher evaluations, curriculum applications and curriculum development (Jones & Moreland, 2005).

In addition, in line with an inquiry-based approach, primary school teachers mentioned the physical conditions (class size and lack of laboratory) as factors affecting their classroom teaching. Additionally, in the face-to-face interviews, teachers noted that they thought the revised programme to be important, but that they experienced difficulties implementing it. In a study performed with 215 secondary school science teachers that questioned their attitudes, beliefs and values toward scientific research (DiBiase & McDonald, 2015), teachers noted the importance of scientific inquiry, but did not have the skills to perform this themselves. They also noted an inability to evaluate students according to the inquiry-based approach and noted difficulties preparing lesson plans. According to the teachers, their students experienced difficulties understanding scientific concepts; teachers also thought the development of scientific process skills among students to be difficult. As a result, teachers believed scientific inquiry to be important; however, there were some difficulties putting this into practice. A study conducted by Ramnarain and Schuster (2014) involving five village and city teachers concluded classroom size, access the information source, school culture and the expectations of parents to be important in the development of PCK; ideal classroom size and a well-configured laboratory triggered the use of an inquiry-based approach and supported the conceptual learning of students. In addition, teachers in schools that were in bad physical condition used tests as an evaluation tool more frequently and according to these teachers, parents with lower socio-economic status wanted their children to take down good notes rather than practising science, because they wanted their children to be employable. This led to teachers using traditional evaluation methods such as tests. The results of the current study show that teachers believe the inquiry-based approach to be useful, but that they view themselves as being inadequately informed about inquiry-based approach. In a study by DiBiase and McDonald (2015) about teachers' beliefs, attitudes and values toward scientific research and questioning, teachers are shown to believe in the

importance of inquiry, but that they did not believe themselves adequately skilful to prepare activities for such an approach. Teachers stated that they were unable to assess their students according to this approach and that they found it difficult to prepare a lesson plan in line with this approach.

According to the results obtained from the current research, participant primary school teachers are insufficient in the field of SMK; they lack PCK components, which negatively affect their teaching. Accordingly, by conducting PCK examinations in all science subjects, the misconceptions of primary school teachers can be defined and preventive, conceptual studies can be conducted. By organizing in-service training activities and providing specialist help, particularly concerning matters that are believed to be missing by the teachers' applications can be initiated commonly. According to Kramarski (2009), supportive programmes for teachers can contribute to their pedagogical knowledge. Similarly, according to Qablan and DeBaz (2015), these programmes can increase teachers' science teaching skills, making them more effective in assessment, teaching and creating teaching plans. This will in turn have a positive impact on their pedagogies. At the conclusion of course for increasing candidate chemist teachers' PCK regarding the nature of science (NOS) by Demirdögen, Hanuscin, Kondakçı-Uzuntiryaki and Köseoğlu (2015), one of the results was that teachers' knowledge about NOS and teaching strategies increased.

In Turkey, a debate on scientific developments can be provided by preparing relevant platforms, beginning with the process of restructuring universities. Where the competencies of teachers are concerned, PCK development during the past 10 years can be discussed. Using these platforms, measures according to PCK perceptions can be implemented, on the based opinions of experienced teachers.



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*Appendix A: Sample coding table.*

Theme	Sub-Theme	Code	Quotations
Personal and professional self	Personal self	Patient	<i>"I wait for the student's answer, I am patient"</i>
	Professional self	To care prize	<i>"I cannot say I am skilful enough in terms of knowledge"</i>
		Valuing students	<i>"I don't put strain on my student[s]. I don't think they have to learn"</i>
Obstacles in learning environment	Physical obstacles	Absence of laboratory	<i>"We can't apply everything as needed as we don't have a laboratory"</i>
		Lack of technology	<i>"We don't have projector or internet access"</i>
Curriculum Information	Positive	Easy access to information	<i>"I think they are learning faster and easier, so when I get feedback, I am happy."</i>
		Interactive learning	<i>"Students have one-on-one interaction and access information themselves"</i>
		Planning	<i>"...have to plan a lesson"</i>
	Negative	Teacher's guide	<i>"We only guide students in science lessons"</i>
Assessment Information	Traditional Assessment methods	Using activity	<i>"We include activities but...I can also use tests"</i>
		Test	<i>"I use tests too often"</i>
		Expressing in sentence	<i>"What is really important to me is that I understand whether the student understands the lesson"</i>
		Behavioural action	<i>"I must make sure that the topic makes sense to the students"</i>
Teaching methods and techniques	Traditional teaching methods and techniques	Lecturing	<i>"I create definitions prior to the lesson"</i>
		Question-and-answer	<i>"We ask and answer questions to better understand the topic"</i>
	Alternative methods and techniques	Drama	<i>"Overall ,children cannot easily keep in mind so we should concretize the topic like dramas"</i>

**Appendix B: Primary teachers' content representation forms.**

Big ideas	A:	B:	C:	D:	E:
	Bones, joints, muscles and skeleton all serve a function in our body's support and movement	Skeletal and muscle health is important	Respiratory system is made up of nose, pharynx, larynx, trachea and lungs	Blood moves through the heart and vessels in our body	There is a connection between exercise and pulse
What you expect students to learn about this idea	<ul style="list-style-type: none"> <li>-Skeletal structure and functions</li> <li>-Bone structure and types</li> <li>-Functions of muscles in support and movement</li> <li>-Types of joints and muscles</li> <li>-That the skeleton, joints and muscles provide body support and movement</li> </ul>	<ul style="list-style-type: none"> <li>-Positive and negative elements in skeleton and muscle health</li> <li>-What can be done for health? <ul style="list-style-type: none"> <li>- How to protect the skeleton and muscle</li> <li>-The importance of physical exercise on the skeletal system in addition to nourishment</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>-Respiratory system organs, their functions, sequences and where they are located in the body</li> </ul>	<ul style="list-style-type: none"> <li>-Circulatory system organs</li> <li>-How blood flows through the body</li> <li>-What does blood consist of?</li> <li>-Functions of circulatory system organs</li> </ul>	<ul style="list-style-type: none"> <li>-Effects of exercise on breathing and the circulatory system</li> <li>-As you do more exercise your pulse rate increases</li> <li>-Relationship between sport and leading a healthy lifestyle</li> <li>-That when you exercise the body expends more energy and breathing increases</li> </ul>
Why is it important for students to know this?	<ul style="list-style-type: none"> <li>-Learning body's support and movement systems</li> <li>-Being healthy and supporting better growth</li> </ul>	<ul style="list-style-type: none"> <li>-The importance of retaining skeletal and muscle health for the future</li> <li>-To know how to maintain a healthy lifestyle</li> </ul>	<ul style="list-style-type: none"> <li>-Important in terms of learning to breathe in the correct manner</li> <li>-In terms of protecting themselves from illnesses</li> <li>-Keeping away from anything that may harm respiration organs</li> </ul>	<ul style="list-style-type: none"> <li>-To know that blood is vital to the body and for caring about nutrition</li> <li>-For knowing the functions of blood, vessels and the heart within their bodies</li> </ul>	<ul style="list-style-type: none"> <li>-For learning the effect of sports on the body's systems and making sport a way of life</li> <li>-To have knowledge about the relationship between exercise types and pulse (for first aid)</li> <li>-To learn what type of sport they can partake in and how they should conduct these activities for a healthy lifestyle</li> </ul>
What else do you know about this idea (that you do not intend students to know yet)	<ul style="list-style-type: none"> <li>-Muscle systems, convulsion and relaxation</li> <li>-The relationship between exercise-pulse-breathing</li> </ul>		<ul style="list-style-type: none"> <li>-Respiratory system organs' health and illnesses in case of unhealthy systems</li> </ul>	<ul style="list-style-type: none"> <li>-Vessel types (artery, vena and capillary)</li> </ul>	-
Difficulties/limitations connected to teaching this idea	<ul style="list-style-type: none"> <li>-To be able understand muscle structure and their convulsion and relaxation</li> <li>-Collaboration between muscles, skeleton and joints for movement</li> </ul>	-	<ul style="list-style-type: none"> <li>-Learning orders of organs</li> </ul>	<ul style="list-style-type: none"> <li>-Movement of blood intracorporeal from bottom to top</li> <li>-Movement of blood through vessels</li> </ul>	-

Knowledge about students' thoughts and how this influences your teaching of this idea	<ul style="list-style-type: none"> <li>-Knowing that the skeleton consists of bones and that it helps movement</li> <li>-That the body is made up of bones and muscles; being healthy</li> </ul>	<ul style="list-style-type: none"> <li>-Benefits of sport</li> <li>-What is the importance of being healthy?</li> </ul>	<ul style="list-style-type: none"> <li>-Breathing oxygen in and breathing carbon dioxide out</li> <li>-Where are the lungs?</li> <li>-What is the shape of the trachea?</li> </ul>	<ul style="list-style-type: none"> <li>-How the heart pumps blood and blood moves throughout the body</li> <li>-What is the colour of blood?</li> <li>-Vessels transport blood</li> </ul>	<ul style="list-style-type: none"> <li>-That pulse rate is different for children and adults</li> <li>-What are the types of exercise?</li> <li>-Where can pulse be controlled from?</li> </ul>
Other factors that influence your teaching of this idea	<ul style="list-style-type: none"> <li>-Question-and-answer</li> <li>-Discussion</li> <li>- Slides monitoring</li> <li>-Experimenting</li> <li>-Observation</li> <li>-Research and practice</li> <li>- Reading, lecturing</li> </ul>	<ul style="list-style-type: none"> <li>-Brainstorming</li> <li>-Question-and-answer</li> <li>-Discussion</li> <li>- Slides monitoring</li> <li>-Experimenting</li> <li>-Observation</li> <li>-Research and practice</li> <li>- Reading, lecturing</li> </ul>	<ul style="list-style-type: none"> <li>-Role-play</li> <li>- Question-and-answer,</li> <li>-Discussion</li> <li>- Slides monitoring</li> <li>-Experimenting</li> <li>-Observation</li> <li>-Research and practice</li> <li>- Reading, lecturing</li> </ul>	<ul style="list-style-type: none"> <li>-Learning through discovery</li> <li>- Question-and-answer</li> <li>-Discussion</li> <li>- Slides monitoring</li> <li>-Experimenting</li> <li>-Observation</li> <li>-Research and practice</li> <li>- Reading, lecturing</li> </ul>	<ul style="list-style-type: none"> <li>-Showing and making</li> <li>- Question-and-answer</li> <li>-Discussion</li> <li>- Slides monitoring,</li> <li>-Experimenting</li> <li>-Observation</li> <li>-Research and practice</li> <li>- Reading, lecturing</li> </ul>
Teaching procedures (and particular reasons for using these to engage with this idea).	-	<ul style="list-style-type: none"> <li>-Conduct questionnaire for older people</li> <li>-Animation</li> </ul>	<ul style="list-style-type: none"> <li>-Watch cartoons</li> <li>-Illustrate breathing on human body model</li> </ul>	<ul style="list-style-type: none"> <li>- Showing and making</li> <li>-Exemplify circulation by conducting an experiment</li> <li>-Have children design their own models with cables while teaching the circulation system</li> </ul>	<ul style="list-style-type: none"> <li>- Showing and making,</li> <li>-Children can be given a list of sporting activities that they can do and the benefits of these activities</li> </ul>
Specific ways of ascertaining students' confusion around this idea (include likely range of responses)	<ul style="list-style-type: none"> <li>-Laboratory method</li> <li>-Animated cartoons</li> <li>-Research, experiments, showing slides about topics</li> </ul>	<ul style="list-style-type: none"> <li>-Animated cartoons</li> <li>-Research, experiments, showing slides about topics</li> </ul>	<ul style="list-style-type: none"> <li>-Animated cartoons</li> <li>-Research, experiments, showing slides about topics</li> </ul>	<ul style="list-style-type: none"> <li>-Animated cartoons</li> <li>-Research, experiments, showing slides about topics</li> </ul>	<ul style="list-style-type: none"> <li>-Animated cartoons</li> <li>-Research, experiments, showing slides about topics</li> </ul>

**AppendixC: PaP-eRs analysis table of primary teachers.**

Education repertory Presentation/teacher	Zeynep	Ozge	Serkan	Esra
Preparation before lesson	-	Yes	-	Yes
Incorrect information about the unit	<ul style="list-style-type: none"> <li>-A tooth is bone</li> <li>-True breathing occurs by lifting shoulders up and down</li> <li>-Circulation occurs as a result of applying force</li> <li>-Deoxygenated blood involves only carbon dioxide Oxygenated blood involves only oxygen</li> </ul>	<ul style="list-style-type: none"> <li>-Blood components are air and nutrition</li> <li>-One of the functions of blood circulation is to assist growth</li> </ul>	<ul style="list-style-type: none"> <li>-A tooth is bone</li> <li>-Penguins do not have joints</li> <li>-Joint movements occur with the help of the brain</li> </ul>	-
Checking students' prior knowledge	-	-	-	- "What is a skeleton? What do you do to stay healthy?"
Teaching methods and techniques	<ul style="list-style-type: none"> <li>-Discourse</li> <li>-Question-and-answer</li> <li>-Demonstration</li> <li>-Brainstorming</li> </ul>	<ul style="list-style-type: none"> <li>-Video</li> <li>-Showing animations and slides</li> <li>-Presentation</li> <li>-Question-and-answer</li> <li>- Ask children to write summary</li> </ul>	<ul style="list-style-type: none"> <li>-Presentation,</li> <li>-Question-and-answer</li> <li>-Ask children to read a book and write a summary</li> </ul>	<ul style="list-style-type: none"> <li>-Presentation</li> <li>-Question-and--answer</li> <li>-Let children lecture</li> <li>-Write a summary</li> <li>-Giving research homework</li> <li>-Simulation</li> </ul>
Evaluating students' knowledge	<ul style="list-style-type: none"> <li>-Through test</li> <li>- Question-and-answer</li> </ul>	<ul style="list-style-type: none"> <li>-Through test</li> <li>-Question-and-answer</li> </ul>	<ul style="list-style-type: none"> <li>-Through test</li> <li>-Question-and-answer</li> </ul>	<ul style="list-style-type: none"> <li>-Through test</li> <li>-Question-and-answer</li> <li>- Application</li> <li>-Delivering oral presentation</li> </ul>
Applied teaching methods and techniques	-A doll made of play dough	<ul style="list-style-type: none"> <li>-Skeletal model</li> <li>-Tent</li> <li>-Lung model</li> <li>-Stethoscope</li> </ul>	-Skeletal model made of paper	<ul style="list-style-type: none"> <li>-Animal skull and piece of meat</li> <li>-Skeleton made of play dough</li> <li>- Tea, chicken wings</li> <li>- Lung model</li> <li>- Respiratory system board</li> <li>-Circulation system board</li> </ul>
Unanswered student questions	"How can our muscles be healthier?"	Students are not given an opportunity to ask questions	"What is keratin?"	-

Given information outside of the lesson acquisition	<ul style="list-style-type: none"> <li>-Placement of anvil, stirrup and hammer</li> <li>-Functions of shinbone and scapula</li> <li>-Structure of smooth and skeletal muscles</li> <li>-Joint and bone types</li> </ul>	Types of joints	Types of joints	-
Student expressions that cannot be corrected				<i>"We can compare blood to a bus that travels throughout a city continuously. Passengers continuously get on and off the bus, just as blood always changes inside the vessels"</i>



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